Connections between the Neutrino and Computing Frontiers

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Computing Frontier Workshop

August 10th, 2020

- Connections
- Structure of the Neutrino Frontier
- Computing Challenges for Neutrinos

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- New experiments will come with new computing challenges. Examples:
  - How do we handle DUNE events too large to hold in memory?
  - How can we leverage machine learning to take full advantage of the power of LAr detectors?
- New computing paradigms create opportunities and challenges. Examples:
  - Processors are gaining cores, not speed, so our code must become parallel, too.
  - HPCs (supercomputers) have potentially enormous resources but using them requires specialized programming.
  - While physics was early to "big data," the rest of the world has caught up. How can we leverage more of the tools and techniques developed *outside* of physics?

Structure of the Neutrino Frontier

- Subgroups organized by “physics goals”:
  - NF01 (3-flavor) Neutrino Oscillations
  - NF02 Sterile Neutrinos
  - NF03 BSM
  - NF05 Neutrino Properties
  - NF06 Neutrino Interaction Cross Sections
  - NF07 Applications
- Subgroups organized by “method”:
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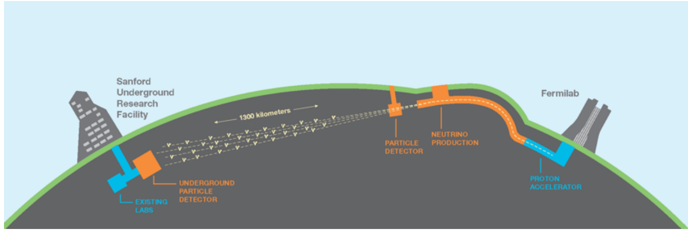

DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

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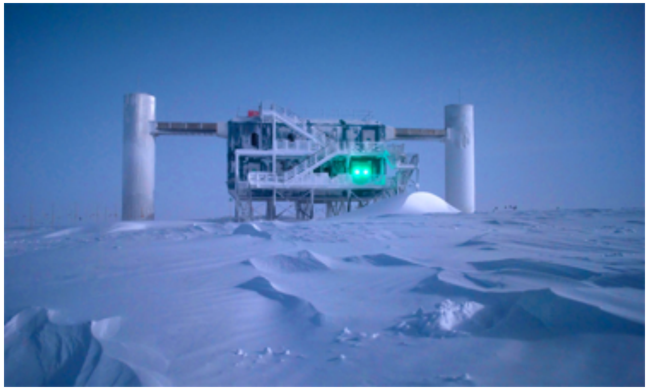

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WATCHMAN

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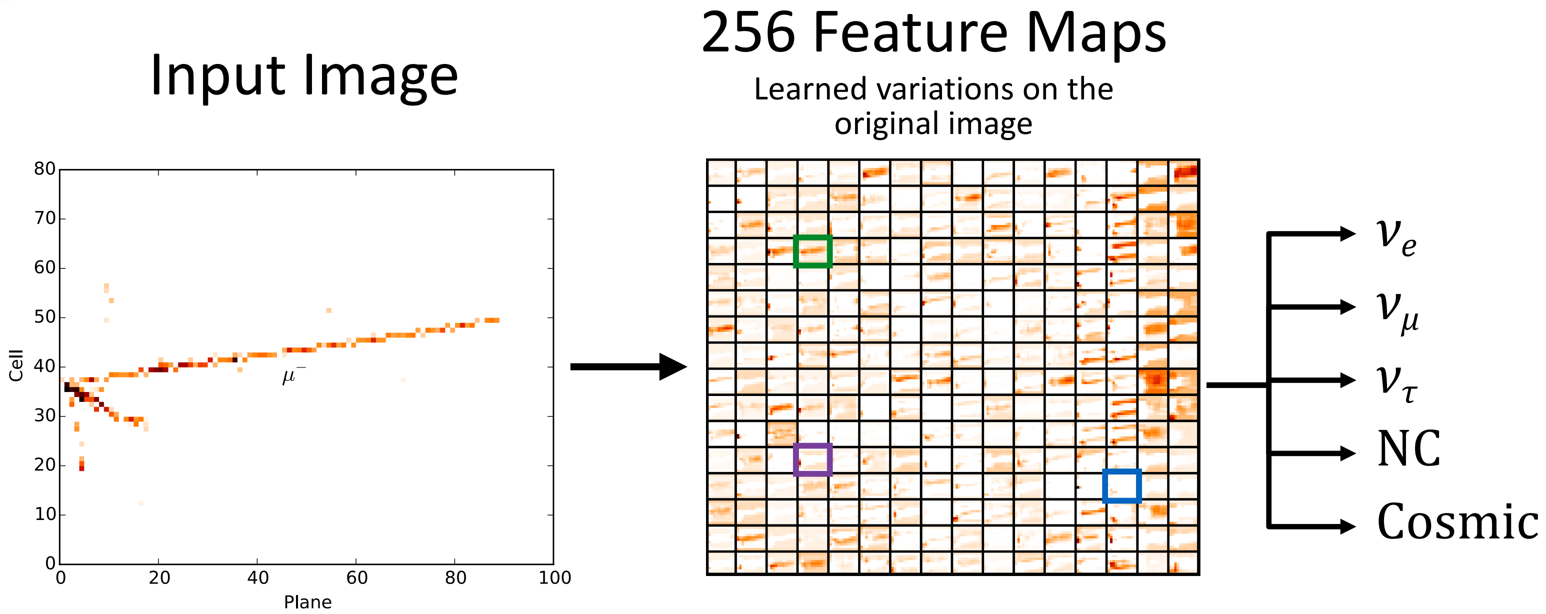
Computing Challenges for Neutrinos

- **Many points of contact**
  - We have a many experiments at different scales and with different needs.
    - For an experiment the size of DUNE there isn't even a single point of contact for the experiment.
  - Small experiments often do not have the resources to develop tools in-house for new computing paradigms. (**CF01, CF04, CF05**)
- Can we devise general solutions that work in multiple contexts?
  - One successful example: LArSoft and the ART framework more generally is in use by a wide-variety of Fermilab experiments which allows the transfer of tools and skills.

Computing Challenges for Neutrinos

- **Problems of Scale:** as experiments get larger (Physical size, amount of data, number of collaborators) the challenges evolve.
- Liquid Argon (Sterile) Oscillation Experiments:
  - LAr experiments, and DUNE in particular, will have very large individual events which require careful memory and disk/tape management. (**CF01, CF04**)
  - LAr reconstruction is relatively slow, and the increasing use of ML algorithms slows it down further, so large scale resources are needed. (**CF01, CF03**)
    - Progress towards multi-threading is very slow.
- Neutrino Property Experiments:
  - Will double-beta experiments run into computing challenges as they increase in size? (**CF04**)
  - What about Project 8 which requires new reconstruction methods? (**CF01**)
- Everyone does analysis (**CF05**):
  - Larger datasets also mean "interactive" analysis gets more and more difficult.
  - Will there be new "analysis clusters" which change this dynamic?
  - What will they look like and how will we train users?

Computing Challenges for Neutrinos



- Neutrino experiments were early and enthusiastic adopters of **machine learning**
  - Stock techniques were well-suited to homogenous imaging detectors
- Some common challenges:
  - How do we think about bias and uncertainty quantification? (**CF03**)
  - How do we handle running these algorithms in current or future production environments? (**CF04**)
  - How does machine learning intertwine with or replace standard reconstruction methods? (**CF01**)

Conclusions

- Please reach out to the Neutrino Frontier folks for the information you need!
  - It's in everyone's best interest for the Computing Frontier to think about the needs of the Neutrino Frontier.
- Subgroup contact information is below, but I am also happy to help when the right connection isn't obvious.

Name	Email List	Slack Channel
Neutrino Frontier	SNOWMASS-NEUTRINO-FRONTIER	
NF01: Neutrino Oscillations	SNOWMASS-NF01-OSCILLATIONS	#neutrino_oscillations
NF02: Sterile Neutrinos	SNOWMASS-NF02-STERILES	#neutrino_sterile
NF03: BSM	SNOWMASS-NF03-BSM	#neutrino_bsm
NF04: Neutrinos from natural sources	SNOWMASS-NF04-NATURAL-SOURCES	#neutrino_natural_sources
NF05: Neutrino properties	SNOWMASS-NF05-PROPERTIES	#neutrino_properties
NF06: Neutrino Interaction Xsec	SNOWMASS-NF06-CROSS-SECTIONS	#neutrino_xsecs
NF07: Applications	SNOWMASS-NF07-APPLICATIONS	#neutrino_nuclear_safeguards
NF09: Artificial Neutrino Sources	SNOWMASS-NF09-ARTIFICIAL-SOURCES	#neutrino_artificial_sources
NF10: Neutrino Detectors	SNOWMASS-NF10-DETECTORS	#neutrino_detectors